PROCEEDINGS OF THE WORKSHOP ON:

THE FISHERIES OF KISORO MINOR LAKES: LAKE KAYUMBU, LAKE CHAHAFI, LAKE MULEHE AND LAKE MUTANDA

"TOWARDS SUSTAINABLE DEVELOPMENT AND MANAGEMENT OF THE FISHERIES RESOURCES OF KISORO MINOR LAKES".

VENUE:	**KISORO COUNCIL HALL**
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INVERTEBRATE COMMUNITITES OF LAKES MUTANDA, MULEHE, KAYUMBU AND CHAHAFI AND THEIR ROLE IN FISHERY PRODUCTION

By:

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Introduction

Kisoro is a small district (734 km^2) located in the highland areas of south western Uganda; bordering with Rwanda in the south, Democratic Republic of Congo in the west and Kabale District in the north and the east. The district contains four medium- to- small lakes namely: Mutanda (26.4 km^2), Mulehe (4.1 km^2), Kayumbu (2.2 km^2) and Chahafi 1.0 km^2). These lakes support small subsistence fisheries for a largely agricultural local population. They are, therefore, locally important as a source of animal (fish) protein, income and employment to the riparian human communities. The fish species include tilapiine fishes: *Oreochromis niloticus, O. leucostictus, Tilapia zillii; Clarias carsoni* (Nsonzi), *Barbus* spp., *Cyprinus carpio* (Common carp) and the red shrimps.

Over the past several decades, both local communities and district authorities have raised considerable concern about poor fish yields from the four lakes. Notably, there has not been any documented ecosystem studies of the four lakes in the past. Nonetheless, the lakes have been stocked with *O. niloticus, O. leucostictus, C. carpio* and *Macropterus salmoides* (Black Bass) at irregular time intervals since 1939.

This study is part of an ecosystem investigation initiated by the Fisheries Resources Research Institute (FIRRI) in November 1998 aimed at identifying the factors contributing to the low fish yields in the lakes, in order to provide a scientific basis for advising the fishing communities and the stakeholders at large. Previous documented studies of the invertebrate communities were undertaken by Green (1964 and 1976) in Lakes Mutanda and Mulehe and were restricted to crustacean micro-invertebrates (zooplankton).

The major objective of the present study was to investigate the composition, distribution abundance, community structure and the trophic relationship between the invertebrate communities and the fishes of the lakes. The latter was aimed at assessing the contribution of aquatic invertebrates to fishery production. A comparative analysis of species composition and abundance of zooplankton on the basis of historical observations of Green (1964 and 1976) was also envisaged in order to keep track of any community changes that may have occurred between the 1960s/1970s and the present time and to establish if such changes relate to the state of the fisheries today.

Materials and methods

Zooplankton samples were taken by vertical hauls with a Nansen type net from 0.5 metres above the bottom sediments. The net meshes used were 50 and 100um. Three hauls were taken at each sampling point at the shallow inshore and in the middle of the lake to make a composite sample. The samples were preserved in 5% sugar-formalin solution. In the laboratory each sample was diluted to ca 600ml with tap water. Each diluted sample was agitated with a glass rod and a series of sub-samples (2, 5 and 10ml) were taken with a calibrated bulb pipette. Each sub-sample was put on a counting chamber under an inverted microscope and examined. Species identification was done using suitable keys and counts were made. Percentage relative abundance data was generated from the counts. Fifty (50) randomly selected individuals of every species were placed on a glass slide and measured from the anterior edge of the head to the posterior end excluding the antennae and terminal setae. Dry weights of organisms were generated using existing data from Bottrell *et al.* (1976).

Fish were sampled with gillnets set over night and retrieved early the following morning. Each fish was dissected, the stomach retrieved and opened up onto a petri dish. The stomach contents were examined under a binocular-dissecting microscope. The different stomach contents were identified and counted where possible. The points method (Hynes 1950) of assessing gut contents was also used.

Results

Species composition, distribution and diversity of zooplankton

The zooplankton communities of the four lakes were composed of largely two taxa of micro-crustaceans: cyclopoid copepods and cladocerans (water fleas) (Table 1). The major non-crustacean taxon was Rotifera, which contained a large number of species. Decapod prawns, *Caridina nilotica* (Roux) represented macro-crustaceans in Lakes Kayumbu and Chahafi. Aquatic insect larvae, composed of mostly *Chaoborus* sp. were also present in all four lakes. Some copepods such as *Thermocyclops schuurmanae* (*oblogatus*?), unidentified *Mesocyclops* species; one cladoceran, *Moina micrura*, and some rotifers such as *Brachionus caudatus, Brachionus falcatus, Keratella tropica and Sychaeta pectinata* occurred in all the four lakes. All four lakes contained a comparable total number of species of invertebrates, ranging between 11-12.

Composition, distribution and abundance of macro-invertebrates

The macro-benthic elements were composed of Chironomid and Chaoborid larvae, decapod prawns (*C.nilotica)*, water mites (Hydracarina), shell snails (gastropods) and some juvenile insects (i.e.Odonata) (Table 2). Chironomid and Chaoborid larvae occurred in three lakes and were missing only in Lake Mutanda while Hydracarina, gastropods and Odonata were found only in Lake Kayumbu. The most abundant macro-benthos in Lake Kayumbu *C. nilotica* (4330 $mgDWm^2$), Hydracarina (160$mgDWm^2$) and gastropods (400mgDWm^2). Chironomid and chaoborid larvae were most abundant in Lake Chahafi (approx. 200mgDWm^2). Lake Mutanda had very low proportions of chironomids and chaoborids while no macro-benthos were recorded in Lake Mutanda.

Inshore-Offshore and seasonal variation in abundance of zooplankton

In most lakes, volumetric abundance of zooplankton (ind.l^{-1}) was higher in offshore compared to inshore areas (Fig.1a). Some seasonal differences in inshore-offshore abundance were also apparent. However, due to limitation of the data, it was not possible to statistically test the observed differences. Comparable trends in inshore-offshore distribution were obtained when the same data was computed as biomass (ugl^{-1}) although variability in seasonal data appeared to be more pronounced (Fig. 1b). High inshore biomass (> 500 ugl^{-1}) was recorded in Lakes Kayumbu and Chahafi but declined to much lower levels in June and July/August 1999 (Fig. 2). Lake Mulehe had lower inshore biomass (< 200ugl^{-1}) but showed a similar seasonal trend as Kayumbu and Chahafi in biomass. The much larger Lake Mutanda had the lowest inshore biomass (< 80ugl^{-1}) and its seasonal trend was markedly different from the other lakes; with low abundance in November 1998, increasing to a peak (ca. 60ugl^{-1}) in June 1999, followed by a slight decline in July/August 1999.

Community structure of zooplankton

Zooplankton size distribution in the four lakes indicated general similarity in the communities (Fig.3). Numerical dominance of cyclopoid copepods and their nauplius larvae was common feature. Rotifers were more abundant in Mutanda, Mulehe and Chahafi than in Kayumbu. On the other hand, Cladocerans had higher abundance in Mulehe and Chahafi compared to Mutanda and Kayumbu. Generally, the large-bodied zooplankters (>1000um) were absent in all lakes and communities were dominated by small-to-medium- bodied organisms. The largest zooplankters were cyclopoid copepods between 800 and 900um body length and were very rare in all the lakes.

Historical changes in zooplankton of Mutanda and Mulehe

Comparison between the community composition of the two lakes as reported by Green (1964 and 1975) and the present study showed that radical changes have taken place (Table 3). Large-bodied cladoceran species such as *Daphnia cuvivostris D. longispina, D. laevis* and *C. reticulata* encountered by Green in Lake Mutanda in 1962 were absent in 1975 and in the present study. So were the large-bodied *Metadiaptomus aethiopicus* (Calanoid copepod) and two macro-benthos: *C. nilotica* and *Chaoborus* larvae. On the other hand, there are some organisms such as the cladocerans: *Ceriodapnia cornuta*, and *Moina micrura* which, appeared in the 1975 and the present samples but were absent in 1962. The third category are organisms such as *Bosmina longirostris, Chydorus* sp. and *Macrothrix* sp. not recorded at all by Green (1964, 1975) but were encountered during the present study. A similar scenario is seen in Lake Mulehe where *C. reticulata, C. nilotica* and *Chaoborus* larvae encountered in 1962 were not found in the 1975 and the present surveys.

Food of fishes

Gut content analysis (Table 4) showed that in Kayumbu and Chahafi *Clarias carsoni*, feeds mainly on chironomid larvae supplemented by *C. nilotica* small fishes, molluscs and detritus while cichlid fishes namely *Tilapia zillii, Oreochromis niloticus* and *Oreochromis leucostictus* consumed mostly macrophyte remains with small proportions of algae and detritus. In Mutanda and Mulehe *Oreochromis niloticus* ingested largely algae and small amounts of macrophyte remains and detritus.

Discussion

The zooplankton composition in the four lakes is comparable. The communities are dominated by medium-sized cyclopoid copepods comprising ony two species: *Thermocyclops schuurmanae* and *Mesocyclops* sp. One cladoceran species, *M.micrura* and several species of rotifers also occur in all the lakes but are much less abundant than the copepods. The densities of zooplankton observed in these lakes are generally low compared to other lakes in Uganda with the exception of Kayumbu which supports > 400 ind.l^{-1}. The low crops of these organisms may be related to poor food quality common in eutrophic systems. Another potential factor is the low water temperatures (15-24^{0}C) arising from the high elevation (> 1800m above sea level) of Kisoro district in general. Low mean temperature reduces metabolic activities leading to low growth and turnover rates of organisms. It is however evident that even the limited crops of of zooplankton are not fully channeled into fishery production owing to no or poor development of pelagic fish communities in Kisoro lakes.

It is worthy of notice that large-bodied zooplankters like calanoid copepods and Daphnids (Cladocera) were not represented in any of the lakes. However, Green (1964) recorded both taxa in Lakes Mutanda and Mulehe. It is therefore evident that drastic ecological changes have taken place in these lakes since the 1960s when Green made his investigations. The changes were detected as early as the mid-1970s when the same author revisited the lakes. Green (1975) attributed the changes to eutrophication (excess nutrient loading) and pollution (contamination with heavy metals). This is supported by increases in human population density over the years coupled with intensified cultivation activities in the hilly catchments probably accompanied by application of insecticides and herbicides which may have found their way into the lakes in addition to soil erosion. Lakes Mulehe and Mutanda have clear signs of eutrophication including frequent algal blooms and high proportions of species of blue-green algae. The latter are known to produce toxic chemicals, which can cause fish kills and mortality of other biota.

Intense selective predation by planktivorous fishes may also contribute significantly to changes in zooplankton composition and species relative abundance (Brooks and Dodson 1965). This however does not seem to apply to Kisoro lakes. Gut contents analysis of the fishes captured during the present survey indicated absence of obligate zooplanktivorous fishes.

The benthic invertebrate community has elements like *C.nilotica*, chironomids , chaoborids, dragonfly larvae (Odonata) and gastropods (shell snails) that are known to be important prey for many fishes. However examination of the gut content analysis indicates only limited use of these prey organisms mainly by the small catfish, *C. carsoni*. The other fishes, which were mainly cichlids fed overwhelmingly on algae and detritus. However, Corbet (1961) has many examples of non-cichlid fishes that thrive on invertebrate organismsm, which do not appear to be utilised in the Kisoro lakes. Over the past decade in Lake Victoria, invertebrates like *C. nilotica* have been reported to be a key forage item for the Nile perch constituting the most important commercial fish species (Ogutu-Ohwayo 1990). It is therefore clear that a sufficient invertebrate food reserve exists in most of these lakes but this energy source does not seem to be efficiently channeled into fishery production.

Conclusions

- Drastic changes in zooplankton composition and community structure have occurred since the 1960s involving disappearance of some large-sized species
- Eutrophication and pollution appear to be the most causes of these changes
- The invertebrate food resource base is yet to be fully channeled into fishery production due to absence of suitable fish species to utilise the available forage organisms

Recommendations

- Further environmental degradation both in the catchment areas and the lake should be checked in order to preserve the lake environments for fishery production
- Fishery production could be enhanced to some extent through manipulation of existing food chains to include invertebrate consumers in future stocking programs.

References

Bottrell, H.H., A. Duncan, Z.M. Gliwitcz, E. Grygierek, A. Herzig, A. Hillsbricht-Ilkowska, H. Kurasawa, P. Larson and T. Weglenska (1976). A review of some problems in zooplankton studies. *Norw. J. Zool.* 24: 419-456.

Brooks, J.L. and S.I. Dodson (1965). Predation, body size and composition of zooplankton. *Science* 150: 28-35.

Corbet, P.S. (1961). The food of non-cichlid fishes in Lake Victoria, with remarks on their evolution and adaptation to lacustrine conditions. *Proc. Zool. Soc. Lond.* 136: 1-101.

Green, J. (1964). Zooplankton of Lakes Mutanda and Mulehe. *Freshwat. Biol.*

Green, J. (1976). Changes in zooplankton of Lakes Mutanda and Mulehe (Uganda). *Freshwat. Biol.* 6: 433-436.

Hynes, H.B.N. (1950). The food of freshwater sticklebacks *Gastrosteus aculeatus* and *Pygosteus pungitius* with a review of methods used in studies of food of fishes. *J. Anim. Ecol.*19: 36-58.

Ogutu-Ohwayo, R.(1990). Changes in the ingested prey and the variations in the Nile perch and other fish stocks of Lake Kyoga and the northern waters of Lake Victoria (Uganda). J. Fish Biol. 37: 55-63.

Table 1. Zooplankton species composition and richness (total number of species) in Kisoro lakes.

	Lakes			
	Kayumbu	**Chahafi**	**Mulehe**	**Mutanda**
Taxa:				
Cyclopoida				
Thermocyclops schuurmanae (oblongatus?)	*	*	*	*
Mesocyclops sp.	*	*	*	*
Cladocera				
Ceriodaphnia cornuta		*		
Chydorus sp.	*			*
Moina micrura	*	*	*	*
Macrothrix sp.				*
Bosmina longirostris	*			*
Rotifera				
Asplanchna spp.		*		*
Brachionus angularis	*	*	*	
B. calyciflorus	*	*		*
B. caudatus	*	*	*	*
B. falcatus	*	*	*	*
Filinia longiseta	*	*	*	
F. opoliensis	*	*	*	
Keratella tropica	*	*	*	*
Polyarthra sp.	*			*
Synchaeta pectinata	*	*	*	*
Trichocerca sp.		*	*	*
Decapoda				
Caridina nilotica	*	*		
Insecta				
Chaoborus larvae	*	*	*	
Species richness (nos.):	**11**	**12**	**11**	**12**

Table 2. Density (D = ind./m^2) and dry weight (DW = ug/m^2) of macro-benthic organisms in Kisoro lakes, July/August 1999.

	Lake Kayumbu		**Lake Chahafi**		**Lake Mulehe**		**Lake Mutanda**	
	D	**DW**	**D**	**DW**	**D**	**DW**	**D**	**DW**
Taxa:								
Chironomid larvae	2	<10	960	200	2	<10		
Chaoborid larvae	4	<10	120	200	9	<10		
Caridina nilotica	2354	4330	820	200				
Hydracarina	208	160						
Gastropods (*Bulinus*)	48	400						
Odonata (Zygoptera)	16							

lakes Mutanda and Mulehe in samples taken by Green (1964 & 1975) and Ndawula & Kiggundu during the present study (1999). * Refer to organisms not found at all by Green but were encountered during the 1998/99 survey.

	Mutanda		
	Oct-62	**Aug-75**	**Jul/Aug-99**
Daphnia curvivostris	11425	0	0
D. longispina	2856	0	0
D.laevis	6292	0	0
Ceriodaphnia reticulata	2828	0	0
C. cornuta	0	360	3395
Moina micrura	0	960	4212
Metadiaptomus aethiopicus	41289	0	0
Cyclopoida	31037	21480	6035
Nauplius larvae	47651	7127	2216
Caridina nilotica	85	0	0
Chaoborus larvae	7636	0	0
Rotifera	990	6140	143175
**Bosmina longirostris*	0	0	356
**Chydorus* sp.	0	0	26
**Macrothix* sp.	0	0	26

	Mulehe		
	Oct-62	**Aug-75**	**Jul/Aug-99**
C. reticulata	10267	0	0
C. comuta	126	660	13819
M. micrura	67872	640	19353
Cyclopoida	145572	7520	2924
Nauplius larvae	186012	5014	66718
C. nilotica	354	0	0
Chaoborus larvae	121	0	0
Rotifera	222140	12032	69265

Table 4.The gut contents of fish species from different lakes in Kisoro.

Fish species:	**Lake Kayumbu**	**Lake Chahafi**	**Lake Mulehe**	**Lake Mutanda**
Clarias carsoni	(n = 14) - Chironomid larvae >95% - *C. nilotica* - Detritus	(n = 12) - Chironomid larvae >95% - Fish remains - Molluscs		
Tilapia zillii	(n = 11) - Macrophyte remains >99% - Algae (*Nitzschia, Synedra)*. - Detritus	(n = 11) - Macrophyte remains >99% - Algae - Detritus		
Oreochromis niloticus			(n = 15) - Algae (> 95%) - Macrophyte remains - Detritus	(n =11) - Algae (> 95%) - Macrophyte remains - Detritus

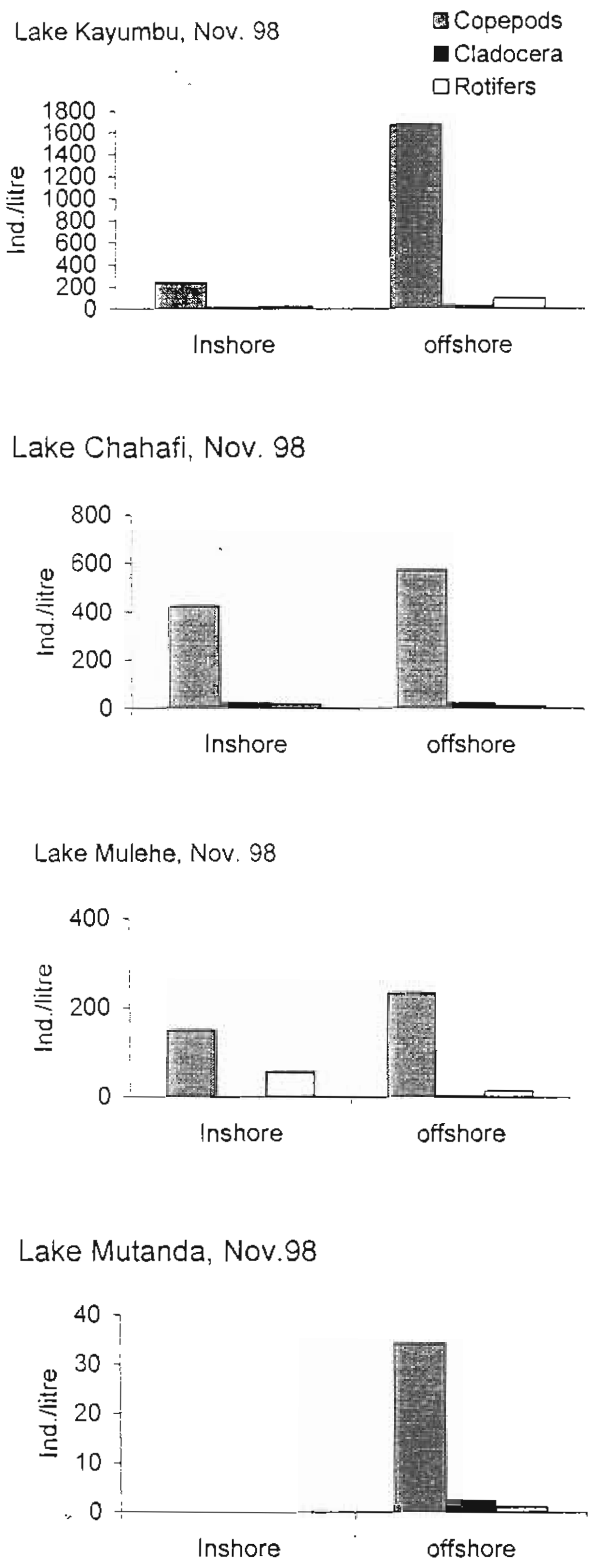

Figure 1a. Inshore-offshore density distribution of zooplankton taxa in Kisoro lakes, November 1998. Note difference in scale for Mutanda.

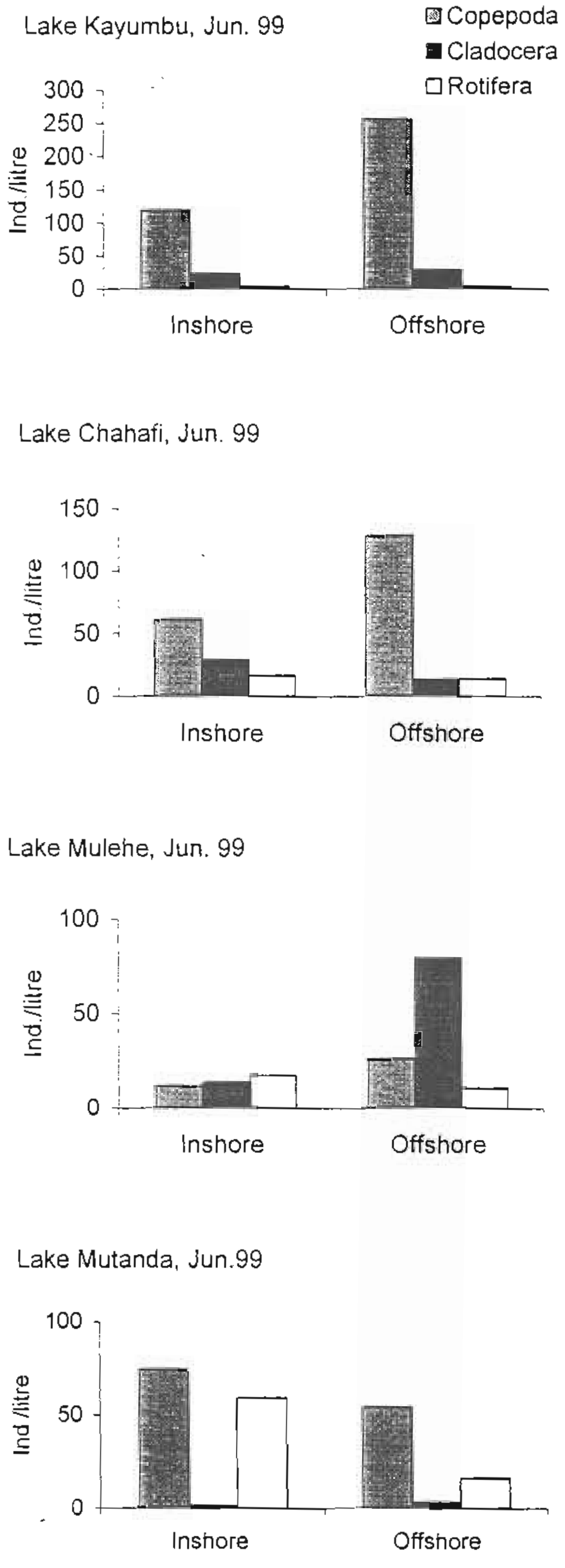

Figure 1a (contd.) Inshore-offshore density distribution of zooplankton taxa in Kisoro lakes, November 1998

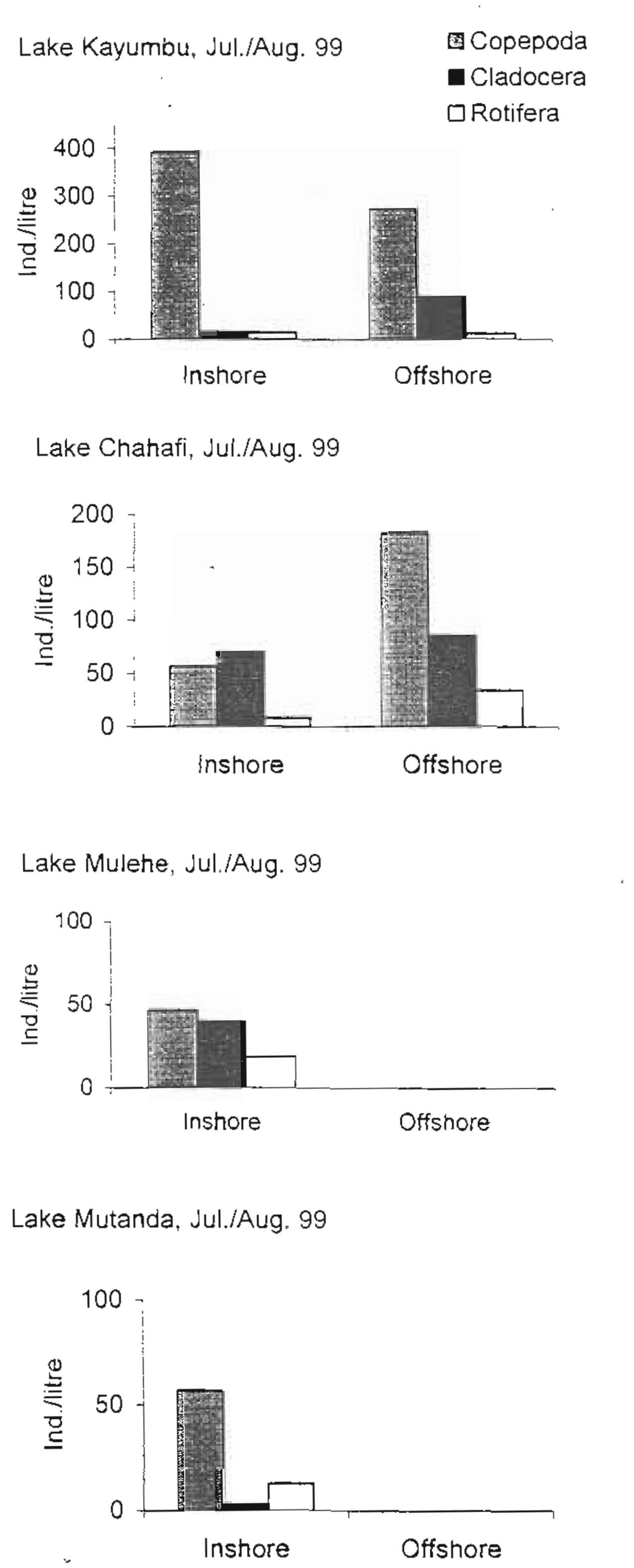

Figure 1a (contd.) Inshore-offshore densitv (Ind.l^{-1}) distributionof different zooplankton taxa in Kisoro lakes, July/August 1999. Note difference in scale for Kayumbu.

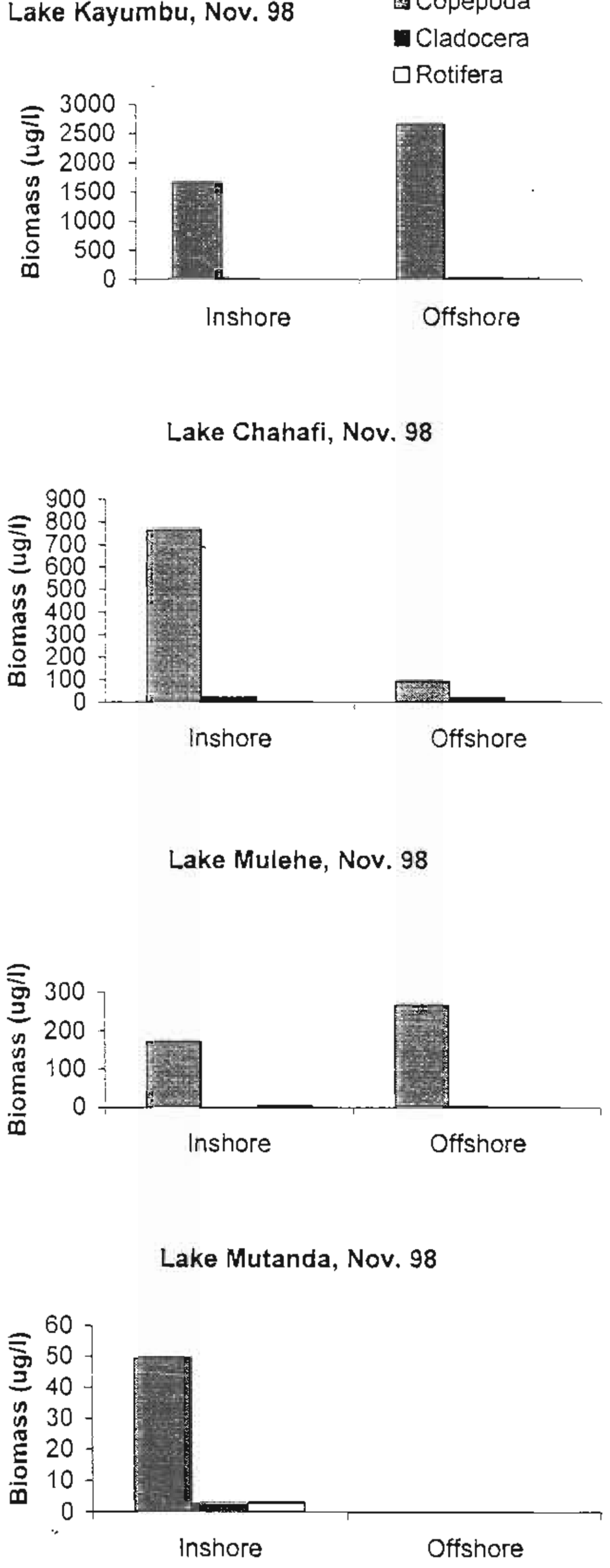

Figure 1b. Inshore-offshore biomass (ug/l) distribution of different zooplankton taxa in Kisoro lakes, November 1998.Note the difference in biomass scale.

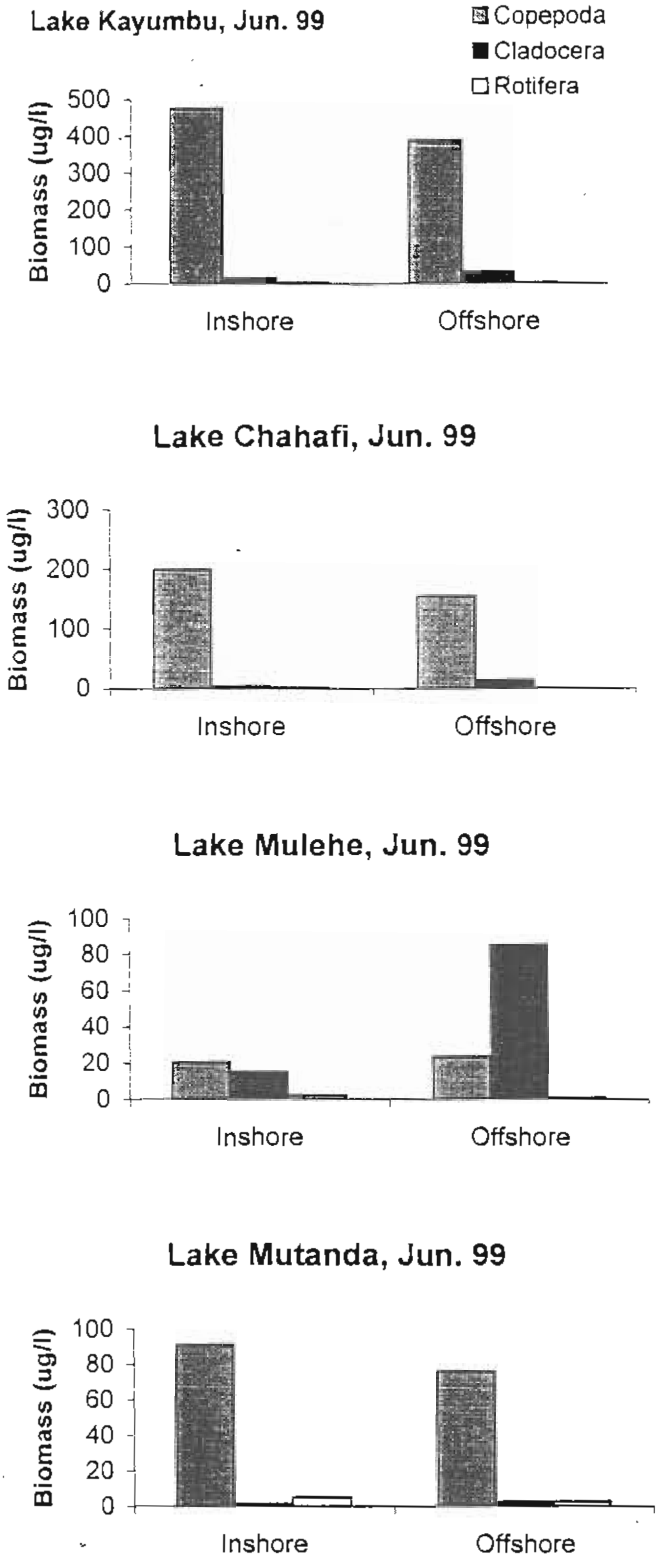

Figure 1b (contd.) Inshore - offshore biomass (ug/l) distribution of different zooplan taxa in Kisoro lakes, June 1999. Note the difference in biomass scale.

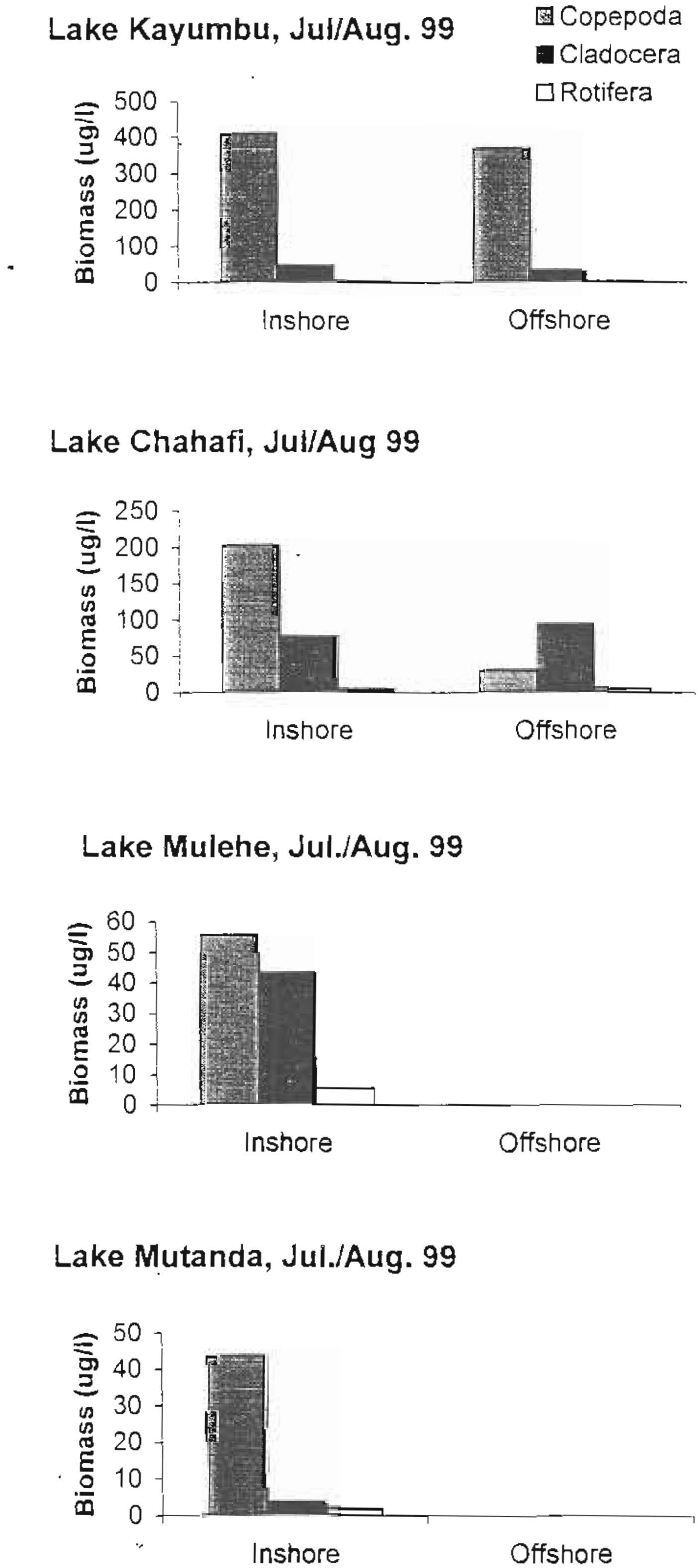

Figure 1b (contd.) Inshore-offshore biomass (ug/l) distribution of different zooplankton taxa in Kisoro lakes July/August 1999. Note difference in Biomass scales.

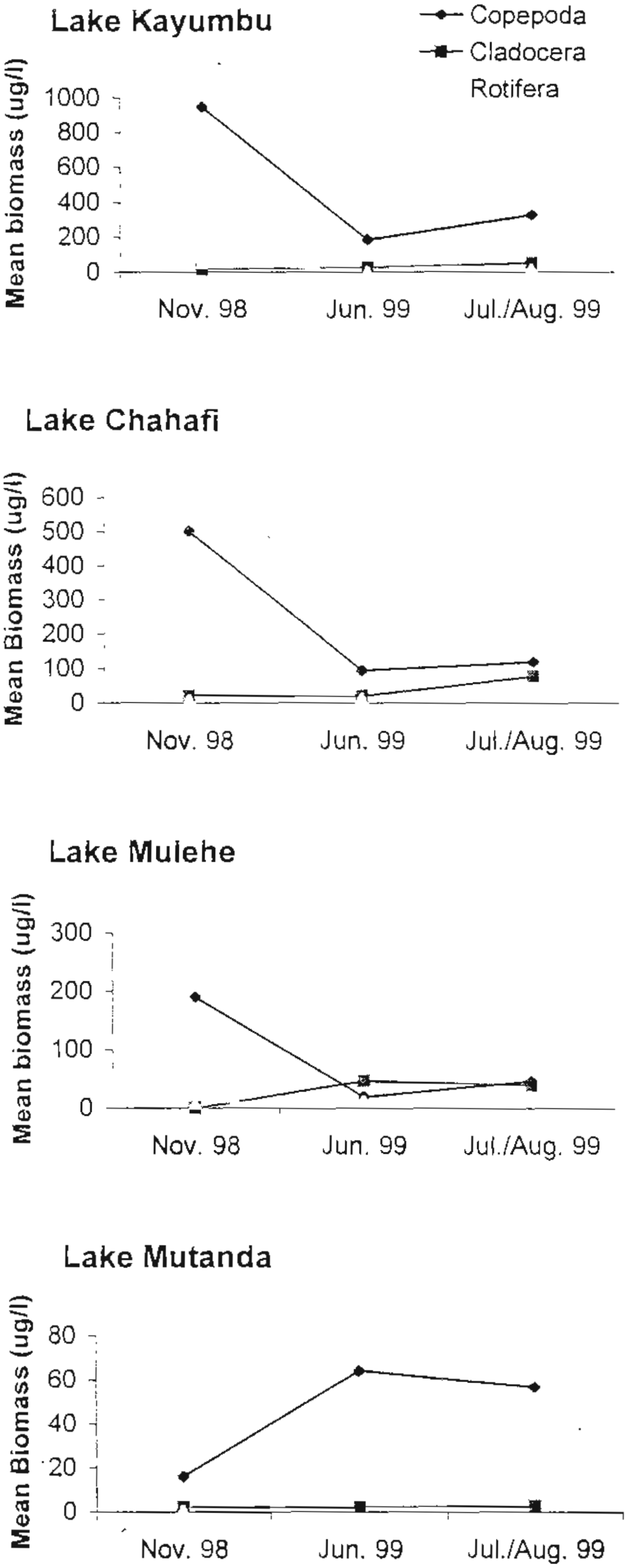

Figure 2. Seasonal vanation of mean inshore biomass (ug^{-1}) of different zooplankton taxa in Kisoro lakes. Note difference in biomass scales.

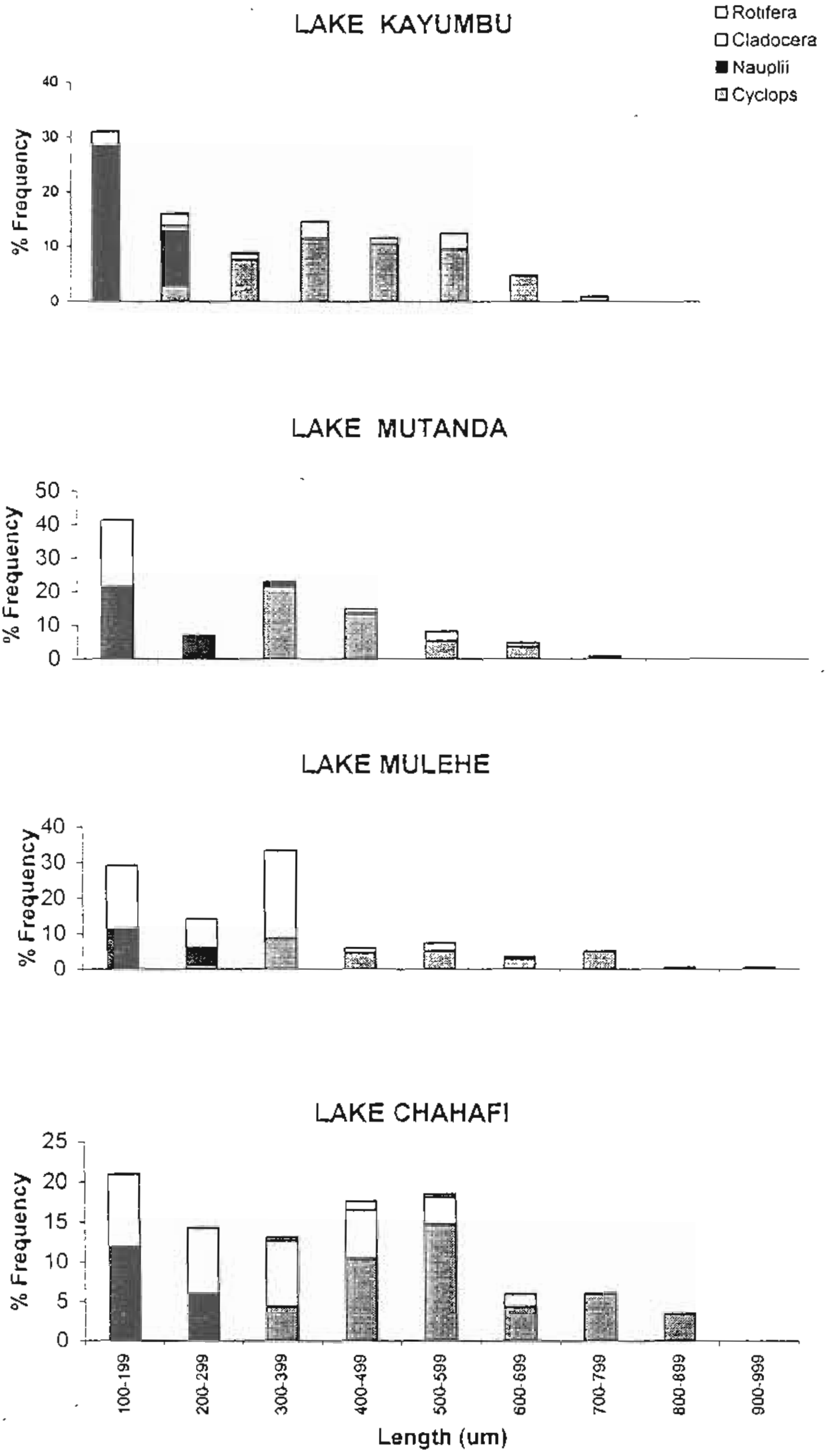

Figure 3. Community size structure of zooplankton of Kisoro lakes, 1998-1999.